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ABSTRACT

The question examined in this paper is: what is known exactly about variables that affect long-term retention of knowledge learned in school? U. Neisser (1982) asserts that "it is difficult to find even a single study, ancient or modern, of what is retained from academic instruction." Further, popular belief holds that much of the knowledge learned in classrooms is forgotten shortly thereafter. Contrary to these assertions, several studies published in content area journals have addressed this question and found substantial long-term retention. These and other studies are examined to determine how much of the knowledge and principles learned in college classrooms is remembered. Several variables that affect the ability to remember are discussed, including the level of original learning, overlearning, the method of instruction, characteristics of the retention interval, the type of information taught and tested, and individual differences in aptitude and motivation. In general, methods that promote higher levels of original learning produce higher levels of retention. A list of 64 references is included. (Author/SLD)

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What Is Remembered?

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Abstract

What exactly do we know about variables that affect long-term retention of knowledge learned in school? Neisser (1982) asserts that " ...it is difficult to find even a single study, ancient or modern, of what is retained from academic instruction" (p. 5). Further, popular belief holds that much of the knowledge learned in classrooms is forgotten shortly thereafter. Contrary to these assertions, a number of studies published in content area journals have addressed this question and found substantial long-term retention. These and other studies are examined to determine how much of the knowledge and principles learned in college classrooms is remembered. Several variables that affect the ability to remember are discussed, including the level of original learning, overlearning, the method of instruction, characteristics of the retention interval, the type of information taught and tested, and individual differences in aptitude and motivation.

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Introduction

A popular myth concerning what students retain from the courses they take in school is reflected in Bahrick's (1979) comment that, "...much of the information acquired in classrooms is lost soon after final examinations are taken" (p. 297). Higbee (1977) makes a similar point in his book on memory. Bahrick (1991) asserts that, "...academic content has been neglected because it consists typically of knowledge and principles (i.e., semantic content rather than episodic content), and experimental research has been unable to study the loss of semantic content" (p. 76).

Memory of knowledge learned in school is an important issue (Naveh-Benjamin, 1900). The very existence of what you and I do rests on the assumption that people remember something of what they learn. This knowledge may be a prerequisite for knowing when and how to perform jobs in the real world, or for making educated choices as consumers and citizens. Thus, it is important to know how and what kind of information students remember.

What exactly do we know about variables that affect long-term retention? According to Bahrick (1979), we do not know nearly as much as we should know given the amount of time we have had to study the phenomenon. Furthermore, Neisser (1982) asserts that "...it is difficult to find even a single study, ancient or modern, of what is retained from academic instruction" (p. 5). However, studies conducted in the first half of this century (Cederstorm, 1930; Eurich, 1934; Greene, 1931; Johnson, 1936; Spitzer, 1939; Tyler,

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1933; Wert, 1937) provide evidence that the situation may not be as bleak as Neisser (1982) would have us believe. These studies, in the areas of zoology, biology, and psychology, found substantial retention from a few months to three years later (Wert, 1937).

In the late 1960s and 1970s, studies that investigated Keller's (1968) Personalized System of Instruction (PSI) and Bloom's (1968) Learning-for-Mastery indicated not only that both methods produced superior academic performance when compared to conventional methods of instruction (Guskey and Gates, 1985; Kulik, Kulik, and Bangert-Drowns, 1990; McMichael and Corey, 1969), but also that students retained more of what they originally learned (Corey and McMichael, 1974). More recent studies have shown that, although some forgetting does occur, particularly of factual details (Rickard, Rogers, Ellis, and Beidleman, 1988), the amount lost (from 10% to 20%) in both absolute and relative terms is small (Cooper and Greiner, 1971; Ellis, 1980; Semb, Ellis, and Montague, 1990). Finally, Bahrick (1983, 1984a, 1984b) and Bahrick, Bahrick, and Wittlinger (1975) reported that even after 50 years, subjects retained a substantial amount of the Spanish they learned in school, details of the towns in which they grew up, and the names and faces of high school classmates.

For a long time, it has been assumed that there is little research on long-term retention (Neisser, 1982). One reason for this may be related to a major problem we encountered -- locating relevant articles. Often, retention measures were included as an

after-thought in an article whose primary emphasis was some other issue (e.g., PSI studies). At other times, they were located in discipline-specific journals such as medical education (Blizard, Carmody, and Holland, 1975; Blunt and Blizard, 1975; Levine and Forman, 1973; Schwartz, 1981; Sinclair, 1965), language instruction (Cohen, 1976; Smythe, Jutras, Bramwell, and Gardner, 1973), civil engineering (Sharples, Smith, and Strasler, 1976), and environmental science (Fagan, 1976). References from these types of sources are not usually cited in educational research articles or in experimental studies of memory.

The lack of articles on retention of knowledge learned in school is a part of the recent controversy between those who advocate naturalistic studies of memory and those who champion controlled experimentation. This controversy was the topic of a recent special issue of the American Psychologist (1991). While each side in the controversy makes persuasive arguments, both seem to call for an integration of the two approaches. It is our position that research on retention of school learning (Bahrick, 1983, 1984a, 1984b; Bahrick, Bahrick, and Wittlinger, 1975; Semb, Ellis, and Montague, 1990; Semb, Ellis, and Araujo, 1991), represents naturalistic settings in which memory for semantic content has been studied under conditions of adequate experimental control.

Variables that Affect Long-Term Retention

As Bahrick (1965) has noted, long-term retention of information learned in the classroom is a complex issue because it can be

influenced by many factors. Farr (1986) has identified several factors that affect retention, including (1) the degree of original learning, (2) the task(s) to be learned, (3) characteristics of the retention interval, (4) the method of instruction, (5) the way retention is tested, and (6) individual differences. We will examine studies related to each of these factors.

One way to conduct a review of this type is to use meta-analytic techniques such as those represented by Guskey and Gates (1985), Kulik, Jaska, and Kulik (1978), Kulik and Kulik (1991), and Kulik, Kulik, and Bangert-Drowns (1990). Unfortunately, given the large number of variables that may influence long-term retention, there are simply not enough well-controlled empirical studies on which to base such an analysis. Thus, we have opted to approach the task within the format of a more traditional literature review.

Definitions

Retention is typically defined by what is remembered on paper-and-pencil tests (Halpin and Halpin, 1982). The standard procedure is to administer a test to determine what is learned, and then, at a later point in time, to administer a test to determine what has been retained (Runquist, 1983). This can be done in several ways. One is to give an end-of-term exam, and then to re-administer it, or questions selected from it, later (Glasnapp, Poggio, and Ory, 1978; Halpin and Halpin, 1982). To avoid possible testing effects, some researchers opt to create a retention test covering the same material but with different questions (Robin and Graham, 1974; Semb,

Ellis, and Montague, 1990). Another method, probably the most instrumental in preventing testing effects, is to use questions on the retention test that cover the material taught but not tested on the end-of-term exam (Breland and Smith, 1974; Runquist, 1983).

One problem with many retention studies is inconsistent use of terms. For example, a test given after a course has been completed is sometimes called a measure of retention (e.g., Yates and Zimbardo, 1977). In others cases, it is a measure of original learning (e.g., McMichael and Corey, 1969; Semb, Ellis, and Montague, 1990). To be consistent across most studies, an exam given immediately after a course is completed is a measure of original learning; an exam given some time after learning is completed is a measure of retention. The time that elapses between the test of original learning and the retention test is the retention interval, which may vary from a few hours to several years (Bahrick, 1984b).

Another problem with studies of retention is difficulty in defining what is lost. Suppose a student, Emily, scores 90% correct on a test of initial learning and 70% correct on a test of retention a year later. Suppose another student, Elmer, scores 70% initially and 50% a year later. In absolute terms, Emily and Elmer both lost 20%, but relative to initial learning, Emily lost 22.2% and Elmer lost 28.6%. This review will discuss retention in terms of both absolute and relative losses.

The Degree of Original Learning

In Farr's (1986) opinion, the most important variable in long-term retention is the degree of original learning. A large number of studies in a variety of disciplines comparing PSI and Learning-for-Mastery to conventional instruction have shown that mastery conditions produced superior academic performance at the end of the course (Kulik, Jaska, and Kulik, 1978; Kulik, Kulik, and Bangert-Drowns, 1990). In over 20 studies that included a retention interval, academic performance was still superior at the end of the interval for students in the mastery condition.

An interesting question is whether higher levels of original learning decrease the relative amount lost over time. That is, is there an interaction between the degree of original learning and the amount of retention? In a recent study, Semb, Ellis, and Montague (1990) examined this issue. They found that students retained a great deal of what they originally learned: approximately 85% after 4 months and about 80% after 11 months. However, PSI students performed better on the end-of-course exam and after 4- and 11-month retention intervals than more conventionally taught students. Similar to what Austin and Gilbert (1973), Corey and McMichael (1974), Ellis (1980) and Sharples, Smith, and Strasler (1976) have found, the rate of loss, both relative and absolute, was the same for both PSI and conventional instruction. That is, there was no significant interaction between the degree of original learning and the amount of retention.

Overlearning

Another aspect of original learning is overlearning. Evidence suggests that overlearning also promotes high levels of retention, but that relationship has not been analyzed in classroom learning. Semb, Ellis, and Araujo (1991) specifically addressed that issue by looking at retention among student proctors.

Proctors are students who have completed the course during a previous semester, typically with a grade of A or B, and who return to serve as peer tutors. They grade quizzes, keep records, give feedback, and provide one-on-one tutoring. Farmer, Lachter, Blaustein, and Cole (1972) have shown that proctoring benefits student performance, and Gaynor and Wolking (1974) have shown that peer proctors benefit from the experience. However, only one study has analyzed proctors' academic performance. In 1977, Arp and Semb (1977) reported that proctors performed better than the students they tutored at the end of the term. However, these results must be interpreted with caution because they were based on observations of only four individuals. At present, no other data are available indicating what proctors retain after proctoring.

The comparison students in the Semb, Ellis, and Araujo (1991) study were the students proctors tutored. Both students and proctors scored near 90% at the end of the course, but after four months, proctors scored significantly higher than their former students. A possible explanation for no differences in original learning is that 90% is near a ceiling for this course. However, tutoring seems to

force proctors to develop a deeper understanding of the course materials, a form of overlearning, that leads to superior retention. This may be due to several factors including increased exposure to course content, continued contact with it, and the experience of tutoring students over it. Finally, these results suggest that there IS an interaction between original learning and retention, because proctors retained relatively more than the students they tutored.

Other aspects of original learning identified by Farr (1986) such as context, quality of learning, and processing strategies have not yet been examined in classroom environments.

Task Characteristics: The Task(s) to be Learned

In the school environment, tasks refer to what the students learn to do. The question of interest is whether different tasks results in different levels of retention.

Early studies (Eurich, 1934; Tyler, 1933; Wert, 1937) analyzed differences among recognition, recall, and application/interpretation questions. (These categories are similar to Bloom's (1956) taxonomy which appeared two decades later). Eurich (1934) compared recall and recognition items and found that students lost more in absolute and relative terms for recall items. Wert (1937) and Tyler (1933) compared recognition and recall items with interpretation and application items in an introductory zoology course and found that the latter skills increased over time whereas recognition and recall performance decreased. Tyler's (1933) results in another zoology course were similar. His students lost information on animal parts

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and technical terms, but the ability to interpret and apply suffered almost no loss after 15 months. Thus, it appears as though different tasks produce different levels of retention with recognition better than recall, and application/interpretation better than both recall and recognition.

Recent studies have yielded more equivocal results. In a study spanning some fifty years, Bahrick (1984b) found that factual knowledge for Spanish learned in school declined dramatically while grammatical knowledge was maintained in a relatively permanent state. In a related study, Schwartz (1981) found that students lost absolutely and relatively more in their abilities to solve unfamiliar problems than they did in their abilities to solve familiar problems or to recall and recognize factual material in a clinical biochemistry course. Breland and Smith (1974) analyzed retention of basic and obscure concepts in introductory psychology. They found that PSI produced better retention of basic material than traditional lecture, but retention of obscure concepts was not affected by the method of instruction. Glasnapp, Poggio, and Ory (1978) used Bloom's taxonomy to categorize items and found that the rate of loss was less for application and comprehension items than for knowledge items. This result and Bahrick's (1984b) finding support the earlier studies, while the other two studies are only partially consistent.

Another partially consistent study was done by Halpin and Halpin (1982). They found that when retention was measured by multiple-choice items, students performed better on conceptual items

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than on knowledge items, but there was no difference when retention was measured by short answer items. The multiple-choice result is consistent with the earlier studies, but the short answer result is not. This is disturbing because the earlier studies did not use multiple-choice questions. A possible problem with the Halpin and Halpin (1982) study is that the end-of-course and retention test items were identical, which was not the case in the earlier studies.

A problem with all of these studies is that the authors did not define item categories nor did they describe or measure how items were categorized. While recall and recognition items are easy to discriminate on the basis of their form (e.g., multiple-choice versus fill-in-the-blank), the same may not be true for familiar and unfamiliar problems (Schwartz, 1981), basic and obscure concepts (Breland and Smith, 1974), or application and comprehension items (Glasnapp, Poggio, and Ory, 1978). While Halpin and Halpin (1982) used guidelines developed by Jenkins and Deno (1971) to construct test items, they did not report how reliably these items fit the two levels of complexity under investigation.

Defining and classifying items are complex tasks that require subject matter experts who are versed not only in course content but also in item and category definitions. Semb, Ellis, and Araujo (1991) addressed this question by defining four types of knowledge items--recognition, recall, comprehension, and mental skills. Content experts were trained to use these definitions and to categorize items reliably. Retention was measured 4 and 11 months

after original learning. Performance on recall items was significantly lower than performance on the other three item types, which is consistent with previous findings. However, there were no differences in retention for recognition, comprehension, and mental skills items, which is at odds with both early and more recent studies. More research is needed with precisely defined item categories to address the discrepancies among these findings.

The Retention Interval

Two important dimensions of the retention interval can affect performance: its length and what happens to the learner during the interval. In research varying length, several studies (Glasnapp, Poggio and Ory, 1978; Greene, 1931; Johnson, 1936; Semb, Ellis, and Montague, 1990; Wert 1937) have shown that the amount retained decreases as the length of the interval increases. Typically, the amount retained declines quickly at first, then declines at a slower rate (Bahrick, 1984b; Spitzer, 1939), but in no study did the amount retained ever return to baseline or pretest levels. This finding is very reliable and is also found in laboratory studies with nonacademic content.

What happens during the retention interval is also going to affect retention. The extreme example is death, where retention goes to zero. Barring such a catastrophe, the question of interest is, what sorts of life events increase or decrease retention?

Wert (1937) studied retention only among students who took no other courses in the discipline (zoology), while Greene (1931)

retested only subjects in advanced courses in the same discipline. As would be predicted, students in advanced courses performed better on the retention test. In a similar study, Pagliaro (1983) compared computer-aided instruction (CAI) alone with CAI plus concurrent lecture and lecture alone in a pharmacology course. Performance on the retention test was significantly higher for all groups than the test of original learning with the CAI lecture group scoring the highest. This unusual finding occurred because the students in this study were pharmacology students and had taken advanced pharmacy courses during the retention interval.

Bahrick (1979) manipulated practice/re-learning during the retention interval. Students re-learned English-Spanish word pairs during six 1-, 7-, and 30-day intersession intervals. One-day intervals lead to more rapid acquisition, but when retention was measured 30 days later, the 30-day interval subjects showed performance gains while 1- and 7-day interval subjects lost information. The same results were obtained in a systematic replication using Chinese characters. In a related study, Landauer and Ainslie (1975) mailed students a practice exam 6 months into a 1-year retention interval and found that students performed at the same level on it as they had on the end-of-term exam. When the same students took the exam at the end of a 1-year retention interval, no loss was reported; a control group that did not take the practice exam had a loss of 0.73 standard deviation units. These data may appear to be at odds with researchers who have reported significant

drops at the end of 6 months and 1-year, but it should be noted that (1) course content emphasized technical information (programming languages), (2) students took open book exams, and (3) the same form of the exam was used at each testing session. Furthermore, students who had the highest retention scores also reported the highest levels of use of the materials on which they had been tested, but the average students reported using less than 10% of it in the actual performance of their jobs. Ellis (1980) also reported very little loss of knowledge information over a six month interval for Navy students on the final examination from their apprentice training school. Although it was not possible to track the students during the interval, presumably they were working in jobs related to their apprentice training. All of these studies show, not surprisingly, that practice, re-learning, advanced training, or continued exposure to or association with the content during the retention interval facilitates retention.

Instructional Strategies (Conditions of Learning)

While the variables affecting retention identified by Farr (1986) are useful, the distinction among them is not always clear. For example, studies that compare mastery and PSI courses with traditional lecture courses, discussed earlier in the context of the degree of original learning, can also be used to illustrate how different methods of instruction affect learning and retention. For example, Smith (1987) recently compared PSI, traditional instruction, and Socratic dialogue. He found that student involvement was

directly related to retention. PSI and Socratic students scored significantly higher than traditionally taught students, suggesting that instruction characterized by personal involvement promotes better retention than instruction that deals primarily with receiving information passively. Finally, several other studies (Gray, 1987; Haemmerlie, 1985; Halpin and Halpin, 1982; Morris, Surber, and Bijou, 1978; Robin and Graham, 1974) have also used retention to compare different teaching procedures. The outcomes of these studies, while interesting, are not as important as the fact that retention was a measure used to compare different instructional procedures.

How Retention is Tested (Conditions of Retrieval)

The section on the tasks to be learned was concerned with differences among types of test items. In this section, we examine how differences between the end-of-course test and the retention test can affect retention outcomes.

Runquist (1983) highlights an important issue in retention research--the relationship of the retention test to the test of original learning and to what was presented in the original learning environment. Is the retention test the same test, a different test with "parallel" items, or a test of material covered in original learning, but not tested? Whatever the relationship, it needs to be precisely specified. It is easy to specify a retention test that is identical to the test of original learning. However, if the retention test is "parallel," the term "parallel" must be defined or measured. For example, Eurich (1934) used identical forms of the

test for original learning and retention to study differences between recall and recognition items. Halpin and Halpin (1982) also used identical tests to compare multiple-choice and short-answer items written at two levels of complexity (knowledge and comprehension) in their study of the effects of studying and testing on retention. However, because they used identical tests, they were not able to determine what was retained--specific items or general knowledge.

The studies by Semb, Ellis, and Montague (1990) and Semb, Ellis and Araujo (1991) attempted to address some of the issues related to same versus different test, and to the order of presentation of the retention tests (same-different versus different-same). Students took two retention tests at the end of each retention interval, the identical test on which they had scored the highest at the end of the course, and a "parallel" form with items they had not before encountered. The results of both studies indicated that students retained specific questions better than "parallel" questions.

Along similar lines, while the order of presentation of the exams (same-different versus different-same) did not affect performance, students had higher scores on the second exam, regardless of whether it was the same or different (Semb, Ellis, and Araujo, 1991). This suggests that students are influenced by the material they encounter on the first exam, a finding that is consistent with Spitzer's (1939) study in which just taking a test promoted higher levels of performance. It is also consistent with Landauer and Ainslie's (1975) use of review exams to promote

retention. The results of all of these studies reinforce the importance of precisely specifying the method of testing retention.

Individual differences.

The only individual difference that has been investigated in retention studies is ability as measured by standardized test scores or grades. The findings are mixed. Bahrick (1984b), Glasnapp, Poggio, and Ory (1978) Johnson (1936), and Spitzer (1939) all found a positive correlation between grades and retention. Semb, Araujo, and Ellis (1991) also found a positive correlation between grades and performance for students who were taught using an instructor-paced version of Bloom's Learning-for-Mastery but not for students taught using Keller's PSI. A possible explanation for this is that PSI produces less variability across individuals, thus lowering the correlation. This explanation is supported by others who have found higher correlations among more traditionally-taught students as compared to mastery or PSI students (Fernald and DuNann, 1975; Morris and Kimbrell, 1977; Taylor, 1975; Whitehurst & Madigan, 1975).

The data for standardized tests are similar to those for grades. Fagan (1976) reports a positive correlation between aptitude and retention, but Semb, Araujo, and Ellis (1991) found no correlation between composite ACT and performance in either PSI or Learning-for-Mastery courses. Shrager and Mayer (1989) reported a significant Aptitude-X-Treatment interaction for retention of technical information. These results suggest that individual differences may play a role in retention. Other variables, such as

socio-economic status, reading ability, and personality factors, have not been explored in the classroom environment.

Summary

Contrary to popular belief, students retain a great deal of what they learn in the classroom. The results of early and recent studies leave questions unanswered, but in general they are consistent with what Farr (1986) has reported about the major variables that affect long-term retention. First, the level of original learning is clearly an important, if not the most important, determinant of retention. Second, the tasks to be learned affect not only what is originally learned but also what is retained. One of the most consistent effects is that recognition tasks are retained at higher levels than recall tasks. Third, although it may be obvious, retention decreases over time as a function of the length of the retention interval, but as Bahrick (1984b) and others have shown, some knowledge, particularly structured or rule-based knowledge such as grammar, may still be accurately remembered even after 50 years. Fourth, instructional methods clearly make a difference. In general, methods that promote higher levels of original learning produce higher levels of retention. Fifth, the similarity between the end-of-course test and the retention test(s) has an effect; performance is poorer on "parallel" tests than it is on identical tests. Finally, individual differences in ability also affect retention.

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